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ENGINEER TOPOGRAPHIC LABS FORT BELVOIR VA A R NILES
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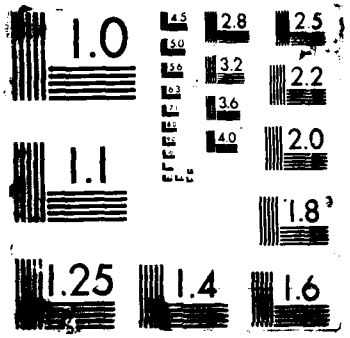
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This report will present software developed at USAETL and the National Geodetic Survey (NGS) to convert between the North American Datum of 1927 and the North American Daturm of 1983. This program was developed in response to a need by the Corps of Engineers' Districts for accurate and easy-to-use software. The report will concentrate on the program capabilities and procedures for use with only brief and general mention of conversion technique.

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DATATRAN: DATUM TRANSFORMATION SOFTWARE

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BIOGRAPHICAL SKETCH

Anthony R. Niles is a Mechanical Engineer graduate of Old Dominion University. His initial projects at the U.S. Army Engineer Topographic Laboratories (USAETL) were with survey and navigation systems for the military. He currently works with the Surveying and Mapping Program for the Topographic Developments Laboratory.

ABSTRACT

This report will present software developed at USAETL and the National Geodetic Survey (NGS) to convert between the North American Datum of 1927 and the North American Datum of 1983. This program was developed in response to a need by the Corps of Engineers' Districts for accurate and easy-to-use software. The report will concentrate on the program capabilities and procedures for use with only brief and general mention of conversion technique.

INTRODUCTION

The North American Datum of 1927 (NAD27) has become unsuitable for present-day surveys. Satellite surveys and accuracy requirements of conventional surveys have dictated the need for a more accurate earth-centered datum. Thus, the North American Datum of 1983 (NAD83) is replacing the NAD27.

In anticipation of this transition, The National Geodetic Survey developed a computer program to convert survey data from NAD27 to NAD83, or vice-versa. This program, called LEFTI, converts geodetic positions (latitude/longitude) using a least squares adjustment. Since Corps of Engineers' Districts often use state plane coordinates, two other programs were developed to convert between geodetic positions and state plane coordinates on either datum. Thus, if a user desired to convert between NAD27 and NAD83 using state plane coordinates, two or more program runs were required. The output from one program was used as the input to the next program. In order to simplify this process, USAETL combined all three programs into one software package, called DATATRAN.

Transformation Technique

As with the program LEFTI, DATATRAN uses a least squares routine to convert between NAD27 and NAD83. At least three reference stations with coordinates in both the old and new

datums are needed. The shifts in these reference stations are applied to the new stations to obtain coordinates in the new datum. Therefore, the accuracy of the transformation is dependent on the accuracy of the reference stations. If first-order reference stations are used, then first-order accuracy is obtained in the transformation.

State Plane or Geodetic Capability

With the integration of the state plane-geodetic conversion programs, DATATRAN offers the flexibility, in some cases, of having inputs/outputs in state plane or geodetic values. If inputs are in state plare coordinates, then the positions are converted to geodetic values for use in the NAD27-NAD83 conversion. If state plane outputs are desired, then the geodetic values output by the NAD27-NAD83 conversion are transformed to state plane values. The current software version does not have the capability of converting NAD83 state plane positions to geodetic values. Therefore, state plane inputs are not available for NAD83 to NAD27 conversions. The following conversions are available with DATATRAN:

1) NAD27 State Plane to NAD27 Geodetic
2) NAD27 Geodetic to NAD27 State Plane
3) NAD27 Geodetic to NAD83 Geodetic
4) NAD83 Geodetic to NAD27 Geodetic
5) NAD83 Geodetic to NAD83 State Plane
6) NAD27 Geodetic to NAD83 State Plane
7) NAD27 State Plane to NAD83 Geodetic
8) NAD83 Geodetic to NAD27 State Plane
9) NAD27 State Plane to NAD83 State Plane

Data Input

Data are entered into DATATRAN for NAD27-NAD83 conversions through two data files. These files follow formats specified in the Federal Geodetic Control Committee publication, "Input Formats and Specifications of the National Geodetic Survey Data Base."

The common point file contains the coordinates on the new datum of the reference, or common, stations. Thus, if NAD83 coordinates are being transformed to NAD27 positions, then this file would contain the NAD27 values for the common stations. Each line in the data file contains the station name, latitude, longitude, and other pertinent information for one station. The format for each station is given in Format A in the Appendix.

The control point file contains the coordinates on the old datum of the stations to be transformed. This file also contains the coordinates on the old datum of the common stations. As with the common point file, each line contains information for one station. The station coordinates can be in geodetic or state plane values. The format for a file of geodetic positions is

given in Format B in the Appendix. Format C gives the structure for state plane coordinates.

Data Output

The output file for geodetic positions follows the same format as the control point file (Appendix, Format B). State plane outputs are listed with the geodetic values in an easy-to-read format. A file of conversion statistics for NAD27-NAD83 conversions is also produced. This file presents the shifts at each station, rotation, residuals, and other information concerning the datum shift.

As mentioned previously, DATATRAN presents the flexiblity of having some inputs/outputs in state plane or geodetic coordinates. The user may perform simple state plane-geodetic conversions on either datum. Inputs for these conversions can be entered interactively or through a data file (batch input).

Sample Program Run

The following presents a sample program run converting NAD27 geodetic coordinates to NAD83 geodetic coordinates. Five common stations and one control station are used. The common file and control file are created prior to the program run using the computer system editor. The common file, following Format A in the Appendix, is as follows:

```
DUP 1924 - SAMPLE FILE          47070784536N122395238255W
HURST 1905 - SAMPLE FILE        47050081643N122304811749W
TACOMA 1905 - SAMPLE FILE       47043710622N122260856576W
SAMPLEV459 - 1986 - FILE        47100935002N122364326962W
RAIN 1905 - SAMPLE FILE         46500533690N122411257305W
```

Examining the first record, there is a station named DUP 1924 - SAMPLE FILE with a latitude of 47 degrees, 7 minutes, and 7.84536 seconds north; and a longitude of 122 degrees, 39 minutes, and 52.38255 seconds west. The other four stations follow similar formats. Note the alignment of the data in each record into specific columns according to the format specification. Any deviation from this alignment will cause a program error or a misread of the data. Since this program run is converting from NAD27 to NAD83, the coordinates are the NAD83 positions of the common stations.

The control file, following Format B in the Appendix, is as follows:

```
*80*    DUP 1924-SAMPLE FILE          47070848400N122394793300W
*80*    TATSOLO 1935-SAMPLE FILE      47072948600N122392914900W
*80*    HURST 1905-SAMPLE FILE        47050145800N122304367300W
*80*    TACOMA 1905-SAMPLE FILE       47043774600N122260413000W
*80*    SAMPLEV459-1986-FILE          47100935002N122364326962W
*80*    RAIN 1905-SAMPLE FILE         46500597300N122410813200W
```

This file contains the NAD27 geodetic positions for the common stations and the control station. Examining the first record, there is a station named DUP 1924 - SAMPLE FILE with a latitude of 47 degrees, 7 minutes, and 8.48400 seconds north; and a longitude of 122 degrees, 39 minutes, and 47.93300 seconds west. The other five stations follow similar formats.

Having created the common and control files, the program is run and the following menu appears:

```
                PROGRAM DATATRAN

     INPUTS MUST BE IN CAPITAL LETTERS

     SELECT FUNCTION:

     1)   STATE PLANE - GEOGRAPHICS, NAD27
     2)   STATE PLANE - GEOGRAPHICS, NAD83
     3)   NAD27 TO NAD83
     4)   NAD83 TO NAD27
     5)   OTHER DATUM TRANSFORMATION

     INPUT FUNCTION NUMBER:
```

The user enters the number corresponding to the conversion desired. For this sample run, a 3 is entered and the following additional menu appears:

```
     SELECT INPUTS/OUTPUTS:

     1)   GEO INPUTS - GEO OUTPUTS
     2)   GEO INPUTS - SP OUTPUTS
     3)   SP INPUTS - GEO OUTPUTS
     4)   SP INPUTS - SP OUTPUTS
```

The user enters the number corresponding to the desired combination of inputs/outputs. For this sample run, a 1 is entered. Recall that a NAD83 to NAD27 conversion with state plane inputs is not possible with this software. Therefore, if a 4 is entered for the initial menu and a 3 or 4 is entered for the second menu, then an error message is displayed and another selection must be made.

The user is then prompted for the names of the control file, the common file, and the output file. The appropriate names consisting of a maximum of eight characters are entered.

The following prompt is then displayed:

```
 DO YOU WANT A FULL LEFTI LISTING WITH -
1 - COORDINATES OF COMMON STATIONS
2 - RESIDUALS AT COMMON STATIONS
3 - TRANSFORMED COORDINATES AND THEIR CORRECTIONS
4 - CHANGES AND INTERSECTION CORNERS
5 - SHIFTS FOR EACH STATION IN SECONDS
6 - SHIFTS FOR EACH STATION IN METERS
    ANSWER Y OR N ???
```

The items listed in this prompt are available for output to the datum conversion statistics file. The user enters a Y if all six items are desired. If an N is entered, then the user chooses which of the individual items, if any, are desired.

The datum transformation is computed. and the final output file is as follows:

```
*80*    DUP 1924-SAMPLE FILE          47070784536N1223952382550W
*80*    TATSOLO 1935-SAMPLE FILE      47072884900N1223933484030W
*80*    HURST 1905-SAMPLE FILE        47050081643N1223048117490W
*80*    TACOMA 1905-SAMPLE FILE       47043710622N1222608565760W
*80*    SAMPLEV459-1986-FILE          47100935002N1223643269622W
*80*    RAIN 1905-SAMPLE FILE         46500533690N1224112573050W
```

This file has the output file name specified by the user and lists the NAD83 coordinates of the control and common stations according to Format B. The conversion statistics file with the items specified by the user is also produced. This file has the output file name specified by the user with the extension ".STS." For example, if the user entered "FILE.OUT" as the final output file name, then this would be the name of the file shown above. The conversion statistics would then have the name "FILE.STS." The conversion statistics file with all six items for this sample conversion is as shown on the following two pages.

CONCLUSION

DATATRAN provides users with an accurate and easy-to-use method for converting between NAD27 and NAD83. The program also offers the flexibility of having inputs/outputs in geodetic or state plane values. Three or more stations with known coordinates on both datums are needed. A least squares adjustment is then applied to the unknown station(s) to determine the coordinate(s) on the new datum.

Reference

Computer Programs "LEFTI", "PCTOGP", and "GPPC83"; National Geodetic Survey - Information Branch, National Oceanographic & Atmospheric Administration, Rockville, Maryland 20852.

COORDINATES OF COMMON STATIONS

STATION	OLD LATITUDE	OLD LONGITUDE	NEW LATITUDE	NEW LONGITUDE
DUP 1924-SAMPLE FILE	47 7 8.48400	122 39 47.93300	47 7 7.84536	122 39 52.38255
HURST 1905-SAMPLE FILE	47 5 1.45800	122 30 43.67300	47 5 0.81643	122 30 48.11749
TACOMA 1905-SAMPLE FILE	47 4 37.74600	122 26 4.13000	47 4 37.10622	122 26 8.56576
SAMPLEV459-1986-FILE	47 10 9.35002	122 36 43.26962	47 10 9.35002	122 36 43.26962
RAIN 1905-SAMPLE FILE	46 50 5.97300	122 41 8.13200	46 50 5.33690	122 41 12.57305

RESIDUALS AT COMMON STATIONS

STATION	NEW LATITUDE	NEW LONGITUDE	RESIDUALS AT N (METERS)	RESIDUALS AT E (METERS)
DUP 1924-SAMPLE FILE	47 7 7.84536	122 39 52.38255		
			-10.975	-26.238
HURST 1905-SAMPLE FILE	47 5 0.81643	122 30 48.11749		
			1.798	-22.353
TACOMA 1905-SAMPLE FILE	47 4 37.10622	122 26 8.56576		
			8.438	-21.666
SAMPLEV459-1986-FILE	47 10 9.35002	122 36 43.26962		
			12.938	61.057
RAIN 1905-SAMPLE FILE	46 50 5.33690	122 41 12.57305		
			-12.199	9.201

TRANSFORMED COORDINATES AND THEIR CORRECTIONS

STATION	OLD LATITUDE	OLD LONGITUDE	NEW LATITUDE	NEW LONGITUDE	RESIDUALS AT N (METERS)	RESIDUALS AT E (METERS)
TATSOLO 1935-SAMPLE FILE	47 7 29.48600	122 39 29.14900	47 7 28.84900	122 39 33.48403		
					-10.496	-24.804

CHANGES AT INTERSECTIONS POINTS SHIFT = NAD83 DATUM - NAD27 DATUM

OLD LATITUDE	OLD LONGITUDE	SHIFT LAT. SEC	SHIFT LON. SEC	NEW LATITUDE	NEW LONGITUDE	SHIFT METERS LAT	SHIFT METERS LONG
46 52 30	122 30 0	-0.91551	4.94837	46 52 29.08449	122 30 4.94837	-27.47	103.92
46 52 30	122 37 30	-0.73982	4.41949	46 52 29.26018	122 37 34.41949	-22.19	92.81
46 52 30	122 45 0	-0.41046	4.40818	46 52 29.58954	122 45 4.40818	-12.31	92.57
47 0 0	122 30 0	-0.61513	4.58732	46 59 59.38487	122 30 4.58732	-18.45	96.33
47 0 0	122 37 30	-0.36481	4.37987	46 59 59.63519	122 37 34.37987	-10.94	91.98
47 0 0	122 45 0	-0.19401	3.98207	46 59 59.80599	122 45 3.98207	-5.82	83.62
47 7 30	122 30 0	-0.60861	3.68802	47 07 29.39139	122 30 3.68802	-18.26	77.45
47 7 30	122 37 30	-0.51476	3.38914	47 07 29.48524	122 37 33.38914	-15.44	71.17
47 7 30	122 45 0	-0.17189	3.51878	47 07 29.82811	122 45 3.51878	-5.16	73.89

JOB STATISTICS

PROJECT TITLE: CONVERSION

	OLD	NEW		SHIFT N	SHIFT E	ROT.ANGLE	SCALE (PPM)
A	6378206.400	6378137.000	VALUE	203.600	-46.938	233.011	24.92
1/F	294.9786982	298.2572221	S.E	27.789	27.789	197.560	958.29
C.M.	122.5833333	122.5833333					

GAUSS-KRUEGER PROJECTION

STANDARD ERROR OF UNIT WEIGHT = 31.573

6 STATIONS
5 COMMON STATIONS

SHIFT = NAD83 DATUM - NAD27 DATUM

NO.	STATION NAME	NAD 1927 DATUM LATITUDE	NAD 1927 DATUM LONGITUDE	NAD 1983 DATUM LATITUDE	NAD 1983 DATUM LONGITUDE	LATITUDE SHIFT (SECONDS)	LONGITUDE SHIFT (SECONDS)
1	TATSOLO 1935-SAMPLE FILE	47 7 29.48600	122 39 29.14900	47 7 28.84900	122 39 33.48403	-0.63700	4.33503

SOME STATISTICS ON THESE DATA:
NUMBER OF POINTS IN AREA = 1

AVERAGE NAD 1983 LATITUDE = 47 DEG 7 MIN 28.85 SEC

AVERAGE NAD 1983 LONGITUDE = 122 DEG 39 MIN 33.48 SEC

POSITION SHIFTS (NAD 1983 MINUS NAD 1927):

AVERAGE LATITUDE SHIFT = -0.637 SECONDS = -19.7 METERS

AVERAGE LONGITUDE SHIFT = 4.335 SECONDS = 91.4 METERS

SHIFT = NAD83 DATUM - NAD27 DATUM

NO.	STATION NAME	NAD 1927 DATUM LATITUDE	NAD 1927 DATUM LONGITUDE	NAD 1983 DATUM LATITUDE	NAD 1983 DATUM LONGITUDE	LATITUDE SHIFT (METERS)	LONGITUDE SHIFT (METERS)
1	TATSOLO 1935-SAMPLE FILE	47 7 29.48600	122 39 29.14900	47 7 28.84900	122 39 33.48403	-19.67	91.37

SOME STATISTICS ON THESE DATA:
NUMBER OF POINTS IN AREA = 1

AVERAGE NAD 1983 LATITUDE = 47 DEG 7 MIN 28.85 SEC

AVERAGE NAD 1983 LONGITUDE = 122 DEG 39 MIN 33.48 SEC

POSITION SHIFTS (NAD 1983 MINUS NAD 1927):

AVERAGE LATITUDE SHIFT = -0.637 SECONDS = -19.7 METERS

AVERAGE LONGITUDE SHIFT = 4.335 SECONDS = 91.4 METERS

APPENDIX

Format A: Common File

1-6	Sequence Number	(optional)
7-10	Blank	
11-13	Station Serial Number	(optional)
14	Blank	
15-44	Station Name	
45-55	Geodetic Latitude: Deg-Min-Sec, to 5 decimal places, decimal point implied between col 50-51 (DDMMSSssssss)	
56	Direction of Latitude: N or S	
57-68	Geodetic Longitude: Deg-Min-Sec, to 5 decimal places, decimal point implied between 63-64 (DDDMMSSssssss)	
69	Direction of Longitude: E or W	
70-75	Elevation of mark above mean sea level, in meters, decimal point implied between 73-74 (EEEEee)	(optional)
76	Elevation code	(optional)
77-78	State or Country Code	(optional)
79-80	Station Order and Type	(optional)

Format B: Geodetic Control File

1-6	Sequence Number	(optional)
7-10	Data Code (*80*)	
11-13	Station Serial Number	(optional)
14	Blank	
15-44	Station Name	
45-55	Geodetic Latitude: Deg-Min-Sec, to 5 decimal places, decimal point implied between col 50-51 (DDMMSSssssss)	
56	Direction of Latitude: N or S	
57-68	Geodetic Longitude: Deg-Min-Sec, to 5 decimal places, decimal point implied between 63-64 (DDDMMSSssssss)	
69	Direction of Longitude: E or W	
70-75	Elevation of mark above mean sea level, in meters, decimal point implied between 73-74 (EEEEee)	(optional)
76	Elevation code	(optional)
77-78	State or Country Code	(optional)
79-80	Station Order and Type	(optional)

Format C: State Plane Control File

1-6	Sequence Number	(optional)
7-10	Data Code (*81*)	
11-13	Station Serial Number	(optional)
14	Blank	
15-44	Station Name	
45-54	X Coordinate, in feet, to three decimal places, decimal point implied between 51-52 (XXXXXXXxxx)	
55-65	Y Coordinate, in feet, to three decimal places, decimal point implied between 62-63 (YYYYYYYYyyy)	
66-69	State and Zone code (SSZZ)	
70-75	Elevation of mark above mean sea level, in meters, decimal point implied 73-74 (EEEEee)	(optional)
76	Elevation Code	(optional)
77-78	State or Country Code	(optional)
79-80	Station Order and Type	(optional)

END

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